

# The 40Hz Auditory Steady-State Response in Sleeping Adults

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## Introduction

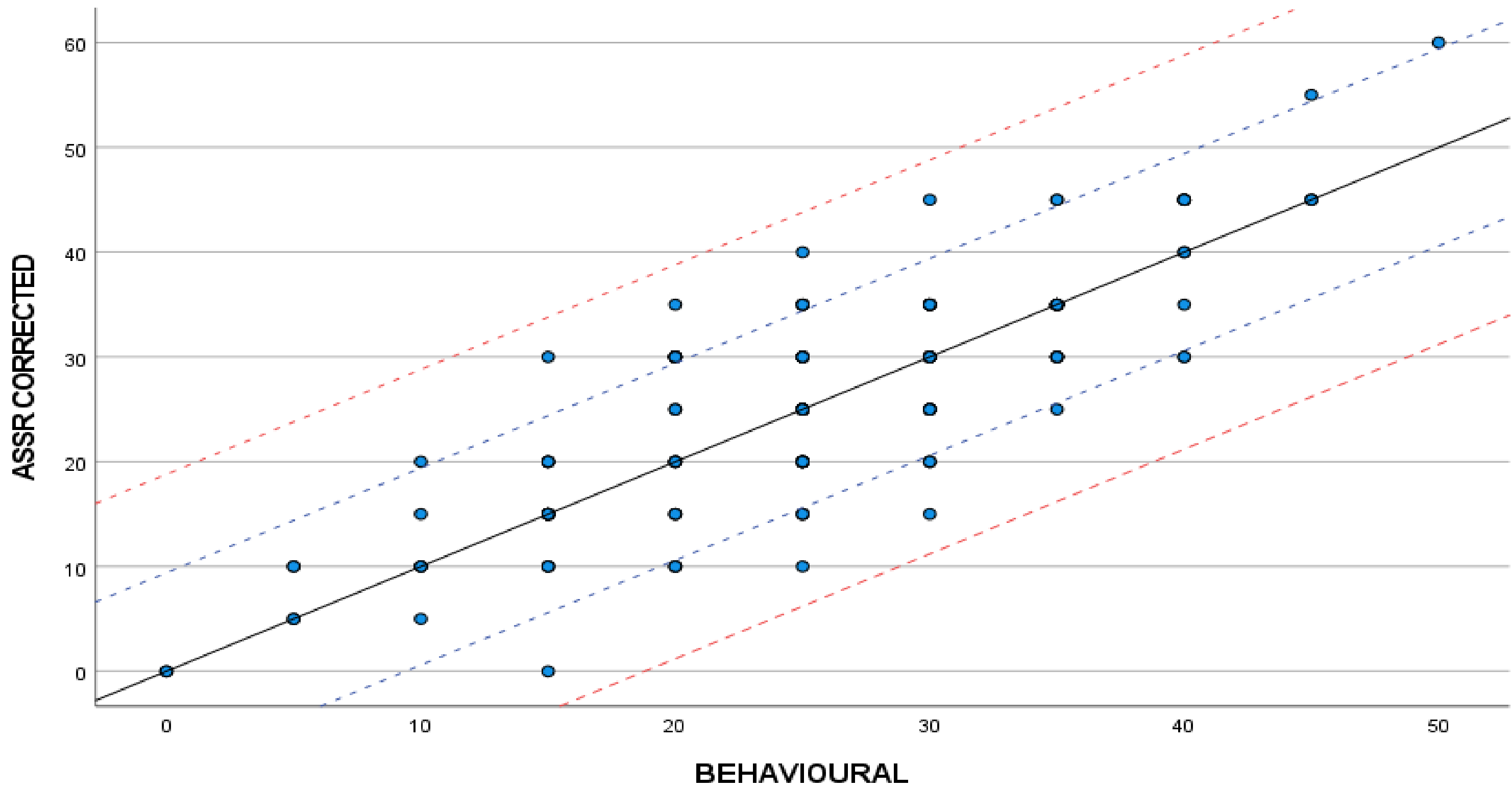
- 40Hz ASSRs is widely thought to be affected by sleep state<sup>1</sup>. Current test protocols suggest that the 40Hz ASSRs be conducted awake, however, patients state can change from awake to asleep.
- Limited evidence suggests that accuracy of the test is not affected by arousal state<sup>2</sup> and is reliably recorded even in anaesthesia.
- Subjects being awake may lead to unwanted muscular noise and possibly prolong testing
- The present study explores whether hearing thresholds can be reliably estimated using 40Hz protocol in asleep adults.

## Methods

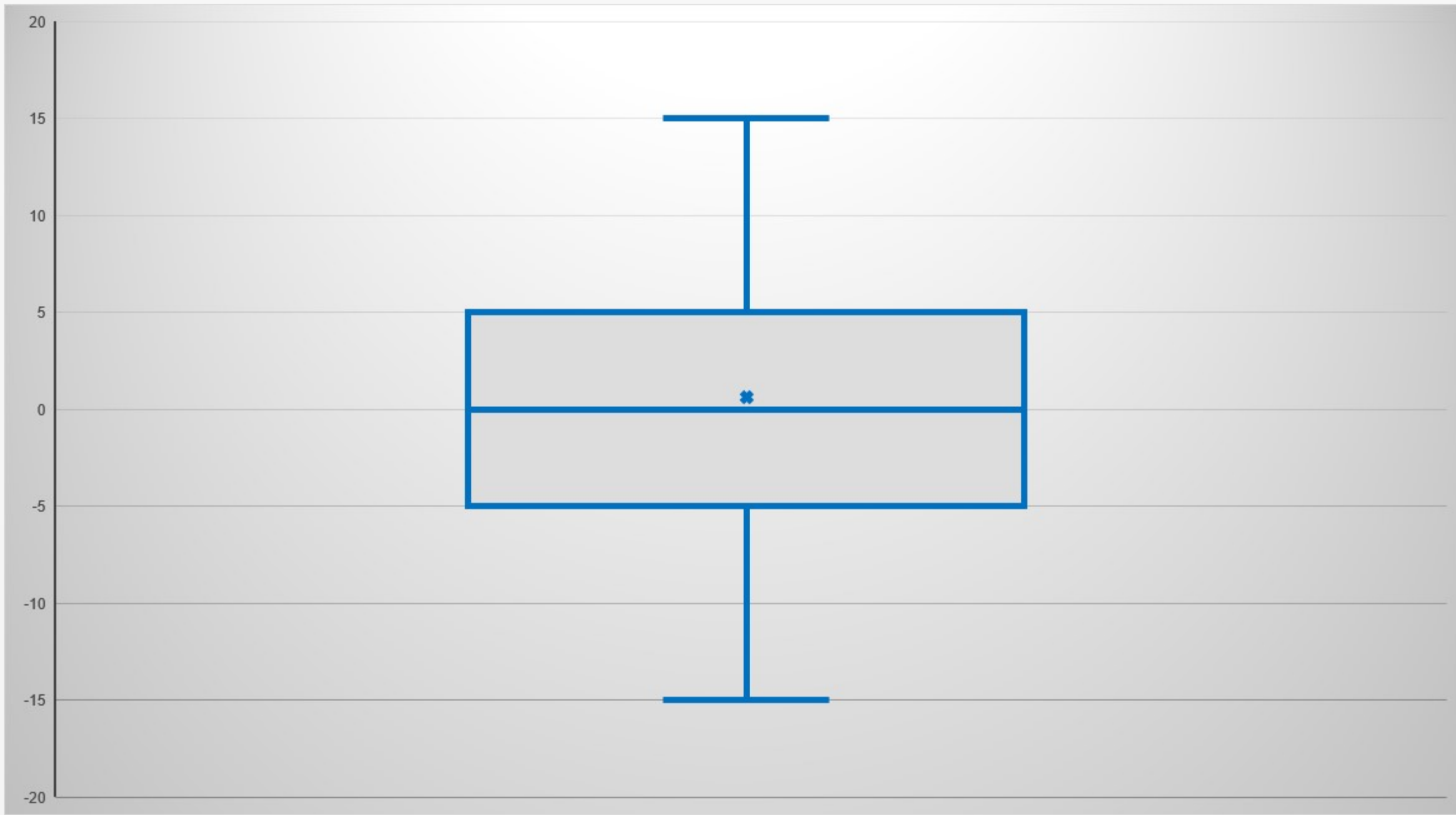
- 20 normally hearing adult participants were recruited
- Hearing loss simulated using ear plugs to avoid noise floor effects
- Thresholds to narrow band chirps (0.5-4kHz) were determined behaviourally
- Participants were then instructed to relax, close their eyes and fall asleep
- Thresholds to the same narrow band chirps were then determined electrophysiologically using the 40Hz ASSRs following the BSA Guidance<sup>3</sup>.
- The Interacoustics Eclipse device was used, with a standard pre-amplifier.
- Behavioural and electrophysiological results were then analysed using Pearson correlations

## Results

- 157 threshold comparisons were made
- Data of participants who did not manage to fall asleep were not included in the current analysis
- Behavioural and electrophysiological thresholds were highly correlated ( $r=0.8$ ) and the correlation was statistically significantly significant ( $p<.001$ ) (Fig 1)
- On average it took 38 minutes to complete testing for four frequencies in both ears (Table 1).



**Fig 1** Scatter plot showing Corrected ASSR in dBeHL threshold vs. Behavioural Threshold in dBnHL. Solid reference line  $x=y$ . Blue dotted lines  $\pm 1$  s.d. Red dotted lines  $\pm 2$  s.d.



**Fig 2.** Box-Whisker plot of differences between Behavioural and Corrected ASSR levels (dB). Cross shows the median, box marks the upper and lower 25% quartile and whiskers denote max. and min. values.

| Descriptive Statistics                                    | N   | Min. | Max. | Mean | SD |
|-----------------------------------------------------------|-----|------|------|------|----|
| Behavioural Threshold(dBnHL)                              | 157 | 0    | 50   | 26   | 9  |
| ASSR Threshold Corrected (dBeHL)                          | 157 | 0    | 60   | 26   | 11 |
| Difference ASSR Corrected (dBeHL) vs. Behavioural (dBnHL) | 157 | -15  | 15   | 0    | 6  |
| Duration of testing (min)                                 | 35  | 20   | 59   | 38   | 11 |

**Table 1.** Data descriptive statistics showing count of measurements (N), minimum and maximum values, mean values and standards deviations (SD).

## Discussion

- 40Hz ASSR testing is a reliable and time-efficient technique for estimating hearing levels irrespective of arousal state.
- The present study was funded by British Society of Audiology (awarded 14<sup>th</sup> April 2025)
- Further work is required to establish the generators of the responses and to compare the test efficiency between awake and asleep conditions
- One of the limitation of the study was that the sleep state could not be evaluated objectively

## References

- Korczak P et al. (2012) Auditory steady-state responses. J Am Acad Audiol. Mar;23(3):146-70.
- Mühler R et al. (2014) 40-Hz multiple auditory steady-state responses to narrow-band chirps in sedated and anaesthetized infants. Int J Pediatr Otorhinolaryngol. May;78(5):762-8.
- BSA (2023) Auditory Steady-State Response Practice Guidance.